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Effect of Soybean Mosaic Potyvirus on Growth and Yield Components of Commercial Soybean Varieties

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Abstract: Soybean mosaic potyvirus (isolates S1 and P1) caused significant reduction in plant height, number of pods/plant, pod length, number of grains/pod and 100 grains weight in mechanically inoculated eight soybean varieties. The reduction in plant height of varieties Recondita, Ajmiri, Kingsay, Weber-84, Swat-84, Epps, Malakand-96 and Kharif-93 due to S1 isolate was 14.9, 15.2, 9.5, 11.0, 45.0, 14.5, 5.2 and 21.1 %, respectively. While in case of P1 isolate the reduction was 6.3, 29.5, 6.0, 47.6, 34.4, 26.2, 1.8 and 15.8 %, respectively. Analysis of variance of the yield components indicated that both isolates (S1 and P1) caused a significant reduction in pod length of all eight varieties. A –4.2 to 23 % reduction occurred in pod length due to S1, while –5 to 24 % reduction was observed in case of P1 isolate. Isolate S1 caused 1.5 to 68.6 % and P1 6.6 to 31.1 % reduction in number of pods per plant. SMV-S1 and P1 caused significant reduction in number of grains per pod. However, the percent reduction due to S1 was 4.8 to 24.7 %, while reduction due to P1 was 10.5 to 29.3 %, respectively. Both isolates affected the weight of grains significantly. The percent reduction was 5.3 to 21.7 and 7.3 to 20 due to SMV-S1 and P1 isolates, respectively.

Key words: *Glycine max*, soybean mosaic potyvirus, yield components

Introduction

Soybean mosaic potyvirus (SMV) is one of the most widely prevalent and economically destructive virus of soybean, *Glycine max* (L.) Merrill in the world as well as in Pakistan. It is a species of the potyvirus genus, particles are contain flexuous rods with a model length of 750x15-18 nm^2 (Galvez, 1963; Ross, 1967; Soong and Milbrath, 1980). Virus particles, ranging from 300 to 900 nm long have also been reported (Soong and Milbrath, 1980); infectivity is highly correlated with the particle size, the most infectious particles being over 656 nm long (Sinclair and Backman, 1989). Nucleic acid in SMV virions have single stranded RNA, constituting 5.3 % of the particle mass and having a molecular weight of $3.25x10^6$d (Hill and Benner, 1980a, b). The virus transmitted in nature by insect vector belonging to the family Aphididae (Abney *et al.*, 1976). Some 16 aphid species including *Acyrthosiphon pisum*, *Aphis faba* and *Myzus persicae* have been reported to transmit the virus in a non-persistent manner (Bos, 1972). Non-vector transmission is through seed and by mechanical means but seed transmission is the most important source of primary infection and disease spread (Bos, 1972; Bowers and Goodman, 1979; Goodman *et al.*, 1979; Goodman and Oard, 1980). SMV produced variable symptoms depending upon the combination of soybean genotype and virus strain (Cho and Goodman, 1979). Most commercial soybean cultivars produce mosaic symptoms when infected with SMV (Bos, 1972; Kwon and Oh, 1980; Lim, 1985). Susceptile cultivars and lines developed severe mosaic, mottling and necrotic symptoms when inoculated with virulent SMV strains (Cho and Goodman, 1982).

Yield losses due to virus infection depends upon virus strains, host genotype, time of infection and prevailing climatic conditions. A 35-50 % crop loss has been reported under natural infections (Ross, 1977; Goodman *et al.*, 1979; Goodman and Oard, 1980; Irwin and Goodman, 1981) and as high as up to 93 % in experimentally inoculated plants (Ross, 1968, 1969; Quiniones *et al.*, 1971; Hill *et al.*, 1987; Sinclair and Backman, 1989). This paper reports the effect of two local isolates (S1, P1) of SMV on growth and yield components of eight experimently inoculated commercial soybean varieties in screen house experiments.

Materials and Methods

Virus isolates and soybean germplasm: SMV isolate S1 was isolated from an infected soybean plant from Experimental Fields of Agricultural Research Station, Mingora, Swat and P1 was isolated from an infected soybean plant at NWFP Agricultural University, Peshawar, experimental fields at Malakandhir in 1999-2000. Both isolates were serologically characterized (Arif and Hassan, 2000) and maintained in soybean cv. Swat-84 and Weber-84 under insect proof screen house conditions. SMV infected seed of soybean varieties Swat-84 and Weber-84 were kept at 4°C and germinated as and when virus isolates were required.

Eight soybean commerical varieties were selected. Seeds of Swat-84, Weber-84, Ricondita, Kingsay were obtained from the Department of Agronomy, NWFP Agricultural University, Peshawar; Malakand-96 from Agricultural Research Station, Mingora, Swat; Ajmeri, Epps and Kharif-93 from Agricultural Research Institute, Tarnab, Peshawar, in 1999-2000.

Plant culture and growth conditions: Seeds of soybean varieties were planted in 26 cm diameter clay pots containing sterilized soil mixture which consisted of field soil, peat, sand and farm yard manure (1:1:1:1: v/v). The experiment was replicated three times in randomized complete block-split plot design (RCB-SPD) in an insect proof screen house. The seedlings were thinned to 6/ pot. Similar plant population was maintained for each variety as untreated control.

Inoculum preparation and virus inoculation: Virus inoculum was prepared by homogenizing leaves of SMV infected Swat-84, Weber-84 having well developed mosaic symptoms (preferably harvested after 3 weeks of virus inoculation) with five volumes (ml/g) of 0.01 M sodium phosphate (pH 7.0) in pestle and mortar or a waring blender. The inoculum was squeezed through a double layer of muslin cloth and was applied on Carborundum (600 mesh) dusted primary leaves by rubbing leaves after dipping forefingers in inoculum or inoculation was made by rubbing leaves with cotton swab that had been dipped into the inoculum. Plants were kept for symptom development in insect proof screen house. After 3 wk of inoculation, plants (particularly symptoms less plants) were back indexed on *Phaseolus vulgaris* cv. top crop (Milbrath and Soong, 1976) and Weber-84 (Arif and Hassan, 2000). The identity of the virus was also confirmed through DAS-ELISA (Arif and Hassan, 2000).

Data on growth and yield components (plant height, pod length, number of pods/plant, number of grains/pod and 100 grain weight) were recorded. Seeds of treated plants of each variety were bagged together, dried uniformed moisture and 100 grain weight was recorded. Data on growth and yield components were statistically analyzed by using least significant difference (LSD) test.

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Results

Effect of SMV isolates on plant height: SMV caused significant reduction in plant height in almost all eight soybean varieties when inoculated with isolate S1 or PI. The prob ability value against treatments is lower than 0.05, the level of significance, it shows that a significant reduction occurred in plant height due to both isolates of SMV (Tables 1, 2). Mean values of the plant height obtained as a result of the application of (LSD) test indicates that percent reduction in plant height of Recondita, Ajmiri, Kingsay, Weber-84, Swat-84, Epps, Malakand-96 and Kharif-93 due to virus isolate SMV-S1 was 14.9, 15.2, 9.5, 11.0, 45.0, 14.5, 5.2 and 21.1 (Table 1) while plant height in case of virus isolate SMV-P1 was 6.3, 29.5, 6.0, 47.6, 34.4, 26.2, 1.8 and 15.8 respectively (Table 2). SMV-S1 that severely affected soybean varieties were Swat-84 (45 %) and Kharif-93 (21.1 %) while virus isolate SMV-P1 caused great reduction in plant height of varieties Weber-84 (47.6 %), Swat-84 (34.4 %), Ajmiri (29.5 %) and Epps (26.2 %) (Tables 1, 2). Less reduction in plant height due to virus isolate SMV-S1 was found in varieties, Kingsay (11 %) and Malakand-96 (5.2 %).

Effect of SMV-S1 and P1 on yield components: Effect of SMV-S1 and SMV-P1 on yield components of eight soybean varieties varied greatly. Data showing the values of different yield components were statistically analyzed using a probability level of 5 %. Analysis of variance showed that all the varieties were severely affected and badly suffered by both isolates.

Effect of isolates SMV-S1 and P1 on pod length: Analysis of variance of the pod length showed that the probability values against treatments was less than 0.05, which indicated that both isolates (SMV-S1, SMV-P1) had caused a significant reduction in pod length of all the varieties (Tables 1, 2). A -4.2 to 23 % reduction occurred in pod length due to isolate SMV-S1, while -5 to 24 % reduction was observed in case of isolate SMV-P1. High reduction by isolate SMV-S1 was recorded in varieties Weber-84 (23 %) and Ajmiri (20.5 %) (Table 1), while isolate SMV-P1 caused more reduction in pod length in Weber-84 (24 %) and Epps (23.7 %) (Table 2). Reduction in pod length did not occur in variety Malakand-96 by none of the virus isolates (Tables 1, 2). SMV isolate SMV-S1 caused less reduction in pod length of Recondita (12.1 %), Kingsay (6.8 %), Swat-84 (12.4 %), Epps (12.3 %) and Kharif-93 (7.5 %) (Table 1) while less reduction in pod length due to SMV-P1 was observed in Recondita (13.3 %), Ajmiri (14.2 %), Kingsay (12.5 %), Swat-84 (16.7 %) and the least reduction in Kharif-93 (2 %) (Table 2).

Effect of isolates SMV-S1 and P1 on number of pods per plant: Since probability value against treatments is less than 0.05, it is concluded that both SMV isolates had caused a significant reduction in the number of pods per plant SMV-S1 and SMV-P1 caused a 1.5 to 68.6 % (Table 1) and 6.6 to 31.1 % (Table 2) reduction in number of pods per plant, respectively. Varieties, Recondita (16.3 %) and Kingsay (12 %) were less affected, while Weber-84 (68.6 %), Epps (43.2 %), Swat-84 (29.5 %) and Ajmiri (23 %) were severely affected by SMV-S1 (Table 1). On the other hand SMV-P1 caused maximum reduction in varieties Weber-84 (31.3 %) and Swat-84 (28.6 %). Varieties Ajmiri (13.3 %). Malakand-96 (15.32 %) and Kharif-93 (14.2 %) were less affected and minimum reduction was found in Recondita (6.6 %) and Kingsay (7.8 %) (Table 2).

Effect of isolates SMV-S1 and P1 on number of grains per pod: Both isolates caused a significant reduction in number of grains per pod. Different varieties have exhibited different responses to both isolates. However, the percent reduction due SMV-S1 (Table 1) and SMV-P1 (Table 2) was 4.8 to 24.7 and 10.5 to 29.3, respectively. Reduction in number of grains per pod was high in varieties, Weber-84 (24.7 %), Swat-84 (22.3 %) and Ajmiri (20.1 %) in case of SMV-S1 (Table 1), while SMV-P1 caused maximum reduction in Weber-84 (29.3 %) and Ajmiri (23 %) (Table 2). Less reduction was caused in Malakand-96 (4.8 %) and (10.5 %) by both isolates, respectively (Tables 1, 2). SMV-S1 caused less reduction in number of grains per pod in varieties Recondita (10.2 %), Kingsay (6.6 %), Epps (16 %) and Kharif-93 (13.8 %) (Table 1), while SMV-P1 caused less reduction in Recondita (11 %), Kingsay (11 %), Swat-84 (14.5 %) Epps (12.1 %) and Kharif-93 (16.6 %) (Table 2).

Effect of isolates SMV-S1 and P1 on 100 grains weight: Both isolates also affected the weight of grains significantly. The percent reduction in 100 grains weight was -5.3 to 21.7 and 7.3 to 20 by SMV-S1 (Table 1) and SMV-P1 (Table 2), respectively. The highest reduction due to isolate SMV-S1 was observed in Swat-84 (21.7 %), while highest reduction by SMV-P1 was observed in varieties, Weber-84 (20 %) and Swat-84 (17 %). Least affected varieties in case of SMV-S1 were Ajmiri (3 %), Epps (3.5 %) and Weber-84 (5.3 %), while SMV-P1 least affected varieties are Epps and Malaknd-96 each showing 7.3 % reduction in 100 grain weight. Varieties Recondita (12 %), Kingsay (7.3 %), Malakand-96 (9.2 %) and Kharif-93 (7.5 %) were less affected by SMV-S1 (Table 1), while Ajmiri (9 %), Kharif-93 (8.9 %), Recondita (15.3 %) and Kingsay (14 %) were the less affected varieties due to isolate SMV-P1 (Table 2).

Discussion

These studies indicated that SMV caused significant reduction in growth and yield parameters of soybean varieties. SMV emerged as one of the major and economically destructive virus problem of soybean crop in NWFP where infection reached to a maximum of 70 % in some of the locations surveyed (Arif and Hassan, 2000). This is mainly due to the seed-borne nature of the virus where in primary source of inoculum was available in the infected seed. This phenomenon has been well documented in the literature (Bos, 1972; Goodman *et al.*, 1979; Goodman and Oard, 1980). Vector acquired virus from primary infected plants and transmitted it easily to the healthy plants. More than 16 species of aphids could transmit the virus with in susceptible soybean germplasm (Bos, 1972; Abney *et al.*, 1976). No immunity was found in local and exotic soybean germplasm tested. However, some resistance was detected in some soybean germplasm (Arif *et al.*, 2000). No delibrate attempt have been made by breeders to incorporate the natural resistance into agronomically desirable varieties for the development of a durable and effective resistance to SMV. Many isolates of the virus have been identified in Pakistan, however, two of them were isolated and well characterized (Arif and Hassan, 2002). Occurrence of SMV epidemics is quite common and easily predictable due to seed borne infection of the virus, presence of a large number of different insect vectors and absence of sources of resistance in the commercial soybean germplasm/varieties in the country.

The issue of crop losses due to SMV has not been addressed properly. A few attempts were made either under natural conditions (Ross, 1977; Goodman and Oard, 1980) or in experimently inoculated soybean plants (Ross, 1968, 1969; Quiniones *et al.*, 1971; Hill *et al.*, 1987). In either cases, the effect of SMV on different growth and yield components for biologically different isolates or strains was not determined. Results of this study indicated that up to a maximum of 45-48 % reduction of growth components have been reported by SMV isolates. Plant virus infection cause reduction of growth components by affecting growth regulating hormones of the plants which are also affected by virus strains, host genotype, time of infection and prevailing climatic conditions. If a susceptible germplasm is challenged to severe virus isolate, the chances of effect on the growth parameters could be maximum which can result in

Table 1: Effect of soybean mosaic potyvirus isolate S1 on yield and growth components of soybean commercial varieties in term of LSD test mean values

	Plant height		Number of pods /plant		Pod length		Number of grains/pod		100 grains weight	
Varieties	Treated/ untreated plants	% reduction	Treated/ untreated plants	% reduction	Treated/ untreated plants	% reduction	Treated/ untreated plants	% reduction	Treated/ untreated plants	% reduction
Recondita	46.93B (55.17A)	14.9	39.0EF (46.6BC-E)	16.3	4.83FG (5.5CD)	12.1	2.9B-D (3.23A)	10.2	11.67F-H (13.26B-F)	12.0
Ajmeri	39.27D-F (46.33B)	15.2	40.0D-F (52.0A-C)	23.0	4.13H (5.2D-F)	20.5	2.26FG (2.83CD)	20.1	12.93C-G (13.33A-F)	3.0
Kingsay	37.8E-G (41.77C-E)	9.5	49.3A-D (56.0AB)	12.0	4.9E-G (5.26DE)	6.8	2.8CD (3.0A-C)	6.6	13.93A-D (15.03A)	7.3
Weber-84	41.57C-E (46.73B)	11.0	18.3H (58.3A)	68.6	3.93H (5.1EF)	23.0	2.13G (2.83CD)	24.7	14.53H (13.8A-E)	5.3
Swat-84	29.07I (52.87A)	45.0	26.3GH (37.3EF)	29.5	5.13D-F (5.86BC)	12.4	2.3FG (2.96A-C)	22.3	11.37GH (14.53A-C)	21.7
Epps	30.93HI (36.2FG)	14.5	25.0GH (44.0C-E)	43.2	5.2D-F (5.93B)	12.3	2.63DE (3.13AB)	16.0	14.4A-C (14.93AB)	3.5
Malakand-96	42.1CD (44.4BC)	5.2	45.0C-E (45.67C-E)	1.5	6.36A (6.1AB)	-4.2	2.76C-E (2.9B-D)	4.8	12.07E-G (13.3A-F)	9.2
Kharif-93	34.9GH (44.23BC)	21.1	34.3FG (56.0AB)	38.7	4.56G (4.93E-G)	7.5	2.5EF (2.9B-D)	13.8	12.27D-G (13.27B-F)	7.5

Table 2: Effect of soybean mosaic potyvirus isolate P1 on yield and growth components of soybean commercial varieties in term of LSD test mean values

	Plant height		Number of pods /plant		Pod length		Number of grains/pod		100 grains weight	
Varieties	Treated/ untreated plants	% reduction	Treated/ untreated plants	% reduction	Treated/ untreated plants	% reduction	Treated/ untreated plants	% reduction	Treated/ untreated plants	% reduction
Recondita	53.37AB (57.0A)	6.3	42.3DE (45.31C-E)	6.6	4.36-F (5.03BC)	13.3	2.9BC (3.26A)	11.0	11.23G (13.27C-E)	15.3
Ajmeri	32.83IJ (46.6CD)	29.5	47.6B-E (55.6A-C)	14.3	4.23EF (4.93B-D)	14.2	2.2GH (2.86C)	23.0	12.4D-G (13.63B-E)	9.0
Kingsay	34.8HI (37.0GH)	6.0	55.3A-C (60.0A)	7.8	4.4EF (5.03BC)	12.5	2.76CD (3.1AB)	11.0	12.8D-F (14.9AB)	14.1
Weber-84	26.37K (50.4BC)	47.6	39.0DE (56.6AB)	31.1	4.0F (5.26B)	24.0	2.0H (2.83C)	29.3	11.1G (13.87B-D)	20.0
Swat-84	35.8G-I (54.57A)	34.4	26.6F (37.3EF)	28.6	5.16BC (6.2A)	16.7	2.53EF (2.96BC)	14.5	11.5FG (13.87B-D)	17.0
Epps	30.63F-H (41.53EF)	26.2	39.0DE (45.0C-E)	13.3	4.6DE (6.03A)	23.7	2.60DE (2.96BC)	12.1	14.7A-C (15.87A)	7.3
Malakand-96	38.53F-H (39.23FG)	1.8	42.0DE (49.6A-D)	15.32	6.2A (5.9A)	-5.0	2.56D-F (2.86C)	10.5	12.17E-G (13.13DE)	7.3
Kharif-93	36.7G-I (43.6DE)	15.8	46.3B-E (54.0A-C)	14.2	4.83CD (4.93B-D)	2.0	2.36FG (2.83C)	16.6	12.6D-G (1.83B-D)	8.9

Means within a column not followed by same letters are statistically significant using 5% LSD test, Information in parenthesis are the values of untreated control plants

complete destruction of the crop. Similarly, effect of the virus on yield parameter such as number of pods/plant, pod length, number of grains/pod and 100 grain weight could further reduce yield and quality of the produce. The individual effect of both isolates of SMV on different growth and yield components of commerical soybean cultivars has been reported. The results indicated that overall effect of virus on both growth and yield components of resistant cultivars such as Malalakand-96 (Arif *et a.*, 2000) was the minimum as compared to susceptible cultivars (Weber-84 or Swat-84) (Arif *et al.*, 2000).

The phenomenon of negative reduction of one of the yield component (pod length) in Malakand-96 against both S1 and P1 isolates is not properly understood. This may be due to agronomic characters of the variety or may be due to some unknown reasons.

The results revealed that a significant role of the virus in affecting and reducing the growth and yield parameters of soybean crop. As previously suggested (Arif *et al.*, 2000) that there is urgent need of development of SMV resistant cultivars by incorporting resistant genes in agronomically desirable soybean varieties through breeding procedures. This will minimize the effect of SMV in soybean germplasm. Meanwhile, soybean varieties such as Malakand-96 and Kingsay having minimum effect of SMV, can be recomemded to the growers for cultivation if other agronomic characters of these varieties are desirable.

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